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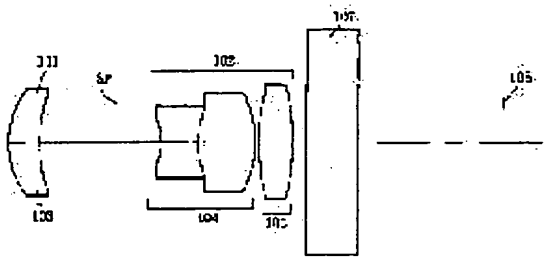
(54) PHOTOGRAPHIC LENS

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain a photographic lens system which is composed of four lenses as a whole and has a high telecentric property and a high optical performance.
SOLUTION: This photographic lens system is composed of a first group, consisting of a meniscus lens having the concave directed to the image side, a second group consisting of a cemented lens where a negative lens having concaves as both lens faces and a positive lens are joined, and a third group consisting of a positive lens in order from the object side, and an aperture stop is provided between the first and second groups, an a focal length f of the entire system, a focal length f1 of the first group, a refraction power ϕ2a of the lens face on the object side of the second group, and a refraction power ϕ3 of the third group are set properly.



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CLAIMS

[Claim(s)]
[Claim 1] The 1st group which consists of a positive lens of the shape of a meniscus which turned a concave surface to an image side sequentially from a body side, In a taking lens which consists of the 2nd group which consists of a cemented lens to which both lens side joined a concave negative lens and a concave positive lens, and the 3rd group which consists of a positive lens, and has an aperture diaphragm between the 1st group and the 2nd group When refractive power of phi2a and the 3rd group is set [a focal distance of the whole system / a focal distance of f and the 1st group] to phi 3 for refractive power of a lens side by the side of f1 and a body of the 2nd group, 0.7<|f1|/f -- < -- 5.0-5.0 -- < -- phi2 a-f -- < -2.01.0 -- < -- phi 3 -f -- < -- A taking lens characterized by satisfying conditional expression of 2.0.
[Claim 2] A taking lens of claim 1 characterized by satisfying conditional expression of 0.30<r1/f< 0.50 in said 1st group when ri is made into radius of curvature of the i-th lens side.
[Claim 3] Claim 1 characterized by satisfying conditional expression of -1.50<f2/f<-0.3 when a focal distance of said 2nd group is set to f2, or 2 taking lenses.
[Claim 4] It is claims 1 and 2 or a taking lens of 3 with which, as for said 2nd group, a concave negative lens and both concave lens side consist [both lens side] of a cemented lens of a convex positive lens, and said 3rd group is characterized by both lens side consisting of a convex positive lens.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates to the taking lens used for a digital still camera, a video camera, the camera for broadcast, a photographic camera, etc.
[0002]
[Description of the Prior Art] In recent years, a digital still camera is spreading as an image input device of a computer. In this digital still camera, the AD translation of the output signal from solid state image pickup devices, such as CCD, is carried out, it considers as image data, and, generally processing in which perform compression processing of JPEG etc. and this is recorded on record media, such as a flash memory, is performed. Thus, the recorded compressed data is displayed on the monitor etc., after being developed on a computer.
[0003] In such a digital still camera, highly-minute-izing of a photography image and the miniaturization of equipment have been a technical problem, and the photography system is asked for coexistence of high resolution and a miniaturization. In order to think especially portability as important and to consider as a thin camera, shortening of an overall length (distance from the 1st lens side to the image surface) is required of a photography system. It is advantageous if a taking lens with as much as possible little configuration lens number of sheets is used for shortening an overall length.
[0004] As such a small taking lens, both the lens side sequentially from a body side to JP,9-258100,A A convex positive lens, The positive lens to which the convex with both the lens side strong against a concave negative lens and image side to which the concave surface strong against a body side was turned was turned, The four four groups configuration of the positive lens to which the convex strong against a body side was turned sequentially from a body side to JP,2-137812,A A positive lens, The meniscus-like positive lens with which the four four groups configuration of a negative lens, a positive lens, and a positive lens turned the convex to JP,64-90409,A sequentially from the body side at the body side, The four four groups configuration of the negative lens to which the field of curvature strong against an image side was turned, the positive lens of the shape of a meniscus which turned the convex to the body side, and a positive lens is indicated. Each of these is four four groups configurations, and is single focal lenses.
[0005]
[Problem(s) to be Solved by the Invention] By the photography system using a solid state image pickup device, since the incident angle to the light-receiving side of an axial outdoor daylight line (chief ray outside a shaft) will become large if the distance from the image surface to an exit pupil is short, problems, such as shading, occur. therefore, the tele cent in which the exit pupil has fully separated the taking lens used for such a solid state image pickup device from the image surface -- rucksack optical system is good.
[0006] Specifically, a taking lens is good to be constituted so that the axial outdoor daylight bunch chief ray which made and carried out incidence of the angle equivalent to an optical axis and a photography field angle may serve as an optical axis and abbreviation parallel and an image formation side may be reached. Refractive power required since the chief ray outside a shaft is

crooked until it becomes parallel to an optical axis becomes strong, so that a photography field angle turns into an extensive field angle.
[0007] if it is generally the last wide angle lens with which a half-field angle would exceed 50 degrees -- refractive power more negative than drawing with a body side -- moreover, it is not necessary to strengthen the optical operation which makes small the angle made with the optical axis of the chief ray outside a shaft by positive refractive power in an image surface side, namely, brings it close to parallel from drawing
[0008] Therefore, even if it does not arrange the pre-group of negative refractive power from drawing to a body side, while being able to make small the angle made with the optical axis of the chief ray outside a shaft by the pre-group with positive power like the taking lens of a retro focus mold, distortion aberration can be amended good. The angle made with the optical axis of the chief ray outside a shaft with the positive lens by the side of the image surface from drawing in the back group of positive refractive power can be made small.
[0009] since [therefore,] it is effective in separating an exit pupil from the image surface by the back group even if there is no **** in a pre-group about a concave lens if it is the last wide angle lens with which a half-field angle would exceed 50 degrees -- a tele cent -- a rucksack exit pupil and a long back focus can attain required small optical system.
[0010] Furthermore, in order to shorten an overall length and to fully detach an exit pupil from the image surface, the last lens of a back group at least needs to consider as a positive lens.
[0011] As for the lens side by the side of the image surface of the lens in front of the last lens, it is still more preferably good that it is a convex toward the image surface.
[0012] Since three lens sides can share the operation which makes the chief ray outside a shaft crooked including the last lens if it does in this way, the refractive power of the last lens does not need to become extremely strong. Since slack type distortion aberration and astigmatism will occur if the refractive power of the last lens is too strong, it is not good.
[0013] Both the lens side of the lens by the side of the image surface is radius of curvature's being the same or considering as abbreviation identitas in a convex most still more desirably. It is on a fabrication and making a biconvex lens into the same radius of curvature can make a fabrication easy at the time of polishing at the time of lens-barrel inclusion.
[0014] Both the lens side is radius of curvature's being the same or considering as abbreviation identitas in a convex about the lens still more desirable nearest to [the degree of the lens by the side of the image surface] the image surface. Making a biconvex lens into the same radius of curvature can make a fabrication easy at the time of polishing at the time of lens-barrel inclusion.
[0015] Furthermore, it is required to make the PETTSU bar sum to some extent small, for making surface smoothness of the image surface good. When there is no negative refractive power into said back group, it is necessary to strengthen the refractive power of the 1st lens of a pre-group considerably to make the PETTSU bar sum small. If the refractive power of the 1st lens is strengthened in this way, the very big slack type distortion aberration as a result will occur. In the common camera containing a digital still camera, big distortion aberration is not desirable. When it has negative refractive power in a back group, the PETTSU bar term in a back group can be controlled to some extent.
[0016] What is necessary is just to set up the PETTSU bar term of a back group so that a pre-group may be amended since the PETTSU bar term of the pre-group which consists of one lens is not amended within a group. Therefore, in order to acquire a good image surface property, it is required for a back group to **** the cemented lens which has one sheet or negative refractive power for a concave lens (negative lens) at least one time.
[0017] In JP,9-258100,A, the sensitivity to each aberration of the air gap between the 3rd negative lens and the 4th positive lens is large. Since the signs of sensitivity especially to spherical aberration and a curvature of field differ, if the above-mentioned air gap shifts from a layout value, the best focus location around a photograph center and a screen will shift to hard flow in the direction of an optical axis to the best focus side on layout.
[0018] A curvature of field occurs as a result, and when a focus is doubled with a photograph center, it becomes the lack of resolution around a screen. It is necessary to manage the

tolerance over the above-mentioned air gap very severely in manufacture to prevent this, and leads to a manufacturing-cost rise.
[0019] Moreover, in JP,2-137812,A, if the camera which takes a photograph by attaching in eye contacting parts, such as an endoscope, a microscope, a binocular, and a telescope, is assumed and it thinks as a usual object for cameras, a back focus will be long beyond the need and an optical overall length will become long.
[0020] moreover -- JP,64-90409,A -- after drawing -- assuming -- **** -- the property top of a lens, and a tele ratio -- amendment of distortion aberration and a curvature of field is difficult at about 1.0. Axial overtone aberration also has insufficient amendment.
[0021] this invention -- an overall length -- being shortened -- an exit pupil -- from the image surface -- enough -- detaching -- in addition -- and it aims at offer of the taking lens which has good optical-character ability.
[0022]
[Means for Solving the Problem] The 1st group to which a taking lens of invention of claim 1 changes from a positive lens of the shape of a meniscus which turned a concave surface to an image side sequentially from a body side, In a taking lens which consists of the 2nd group which consists of a cemented lens to which both lens side joined a concave negative lens and a concave positive lens, and the 3rd group which consists of a positive lens, and has an aperture diaphragm between the 1st group and the 2nd group When refractive power of phi2a and the 3rd group is set [a focal distance of the whole system / a focal distance of f and the 1st group] to phi 3 for refractive power of a lens side by the side of f1 and a body of the 2nd group, it is
$0.7<|f1| / f< 5.0$. ..... (1)
$-5.0 -- < -- Phi2\ A-f -- < -2.0$ ..... (2)
$1.0 -- < -- phi\ 3\ -f -- < -- 2.0$ ..... (3)
It is characterized by satisfying ********.
[0023] Invention of claim 2 is $0.30<r1/f< 0.50$, when ri is made into radius of curvature of the i-th lens side in said 1st group in invention of claim 1. ..... (4)
It is characterized by satisfying ********.
[0024] Invention of claim 3 is $-1.50<f2/f<-0.3$, when a focal distance of said 2nd group is set to f2 in claim 1 or invention of 2. ..... (5)
It is characterized by satisfying ********.
[0025] It is characterized by, as for said 2nd group, for a concave negative lens and both concave lens side consisting [both lens side] of a cemented lens of a convex positive lens in claims 1 and 2 or invention of 3 in invention of claim 4, and both lens side consisting of a convex positive lens, as for said 3rd group.
[0026]
[Embodiment of the Invention] The lens cross section of the numerical examples 1-5 of the taking lens of this invention, drawing 2 , drawing 4 , drawing 6 , drawing 8 , and drawing 10 of drawing 1 , drawing 3 , drawing 5 , drawing 7 , and drawing 9 are aberration drawings of the numerical examples 1-5 of the taking lens of this invention.
[0027] In a lens cross section, the pre-group of refractive power positive in 101 and 102 are the back groups of negative refractive power as a whole. An image formation side and SP of the 1st group of refractive power positive in 103, the 2nd group of refractive power negative in 104, the 3rd group in which 105 has positive refractive power, the filter group by which 107 is constituted from a Xtal low pass filter, an infrared cut-off filter, etc., and 108 are aperture diaphragms.
[0028] In order [side / body], the taking lens of this invention consists of the 2nd group 104 of the 1st group 103 of positive refractive power, and negative refractive power as a whole, and the 3rd group 105 of positive refractive power. And the 1st group 103 of positive refractive power consists of the positive lens of the shape of a meniscus which turned the concave surface to the image surface side, a concave negative lens and a concave positive lens consist [both the lens side] of the cemented lens of a convex positive lens, both the lens side consists of a convex positive lens, and the whole system consists of [the 3rd group 105] three groups [four] for the 2nd group 104.
[0029] And high optical-character ability has been obtained, keeping away an exit pupil from the

image surface and maintaining tele cent rucksack nature good by satisfying above-mentioned conditional-expression (1) - (3).
[0030] Next, the above-mentioned monograph affair type is explained.
[0031] Conditional expression (1) is a formula which has specified, the focal distance, i.e., the refractive power, of the 1st group.
[0032] If a maximum is surpassed and refractive power becomes weaker, the operation which keeps away an exit pupil from the image surface by the 1st group will become weaker. If it is going to keep away an exit pupil from the image surface in the refractive power of a back group so that this may be compensated, since it becomes impossible to have to be in slight strength about the refractive power of the convex in a back group, but to make the PETTSU bar sum small and a curvature of field occurs, it is not good. moreover -- if it is going to keep away an exit pupil from the image surface without strengthening the refractive power of a back group -- recon with a long overall length -- a PAKUTO camera cannot be constituted.
[0033] Moreover, if a minimum is surpassed and refractive power becomes strong, even if distortion aberration and astigmatism occur too much and use the aspheric surface by the 1st group, amending will not be easy to become difficult. Moreover, it becomes difficult for a back focus to become short and to shorten an optical overall length.
[0034] Conditional expression (2) is a formula which has specified the refractive power (inverse number of a focal distance) of the lens side by the side of the body of the 2nd group, and is a numerical range for mainly making amendment of spherical aberration, and the PETTSU bar sum into the optimal value in balance with many aberration.
[0035] If a maximum is surpassed and refractive power becomes weaker, while it becomes impossible to be unable to amend the spherical aberration generated with other positive lenses, the PETTSU bar sum will become large and a curvature of field will serve as lack of amendment. Moreover, if refractive power becomes strong exceeding a minimum, it is accompanied also by generating of comatic aberration, and it not only becomes superfluous amending spherical aberration, but while it is not desirable, the PETTSU bar sum will become large to a negative value, and a curvature of field will become superfluous [****].
[0036] Conditional expression (3) is a formula which has specified, the inverse number, i.e., the refractive power, of a focal distance of the 3rd group.
[0037] If a maximum is surpassed and refractive power becomes weaker, it will become difficult for a back focus to become long and to shorten an optical overall length. Moreover, if a minimum is surpassed and refractive power becomes strong, it will become difficult to suppress generating of many aberration and to obtain good optical-character ability. Amending becomes difficult, even if too much spherical aberration occurs and it uses the aspheric surface especially.
[0038] It is good to satisfy at least one of the next configurations to the taking lens of this invention still more preferably by the above configurations, although it has high optical-character ability over the whole screen.
[0039] (**-1) When ri is made into the radius of curvature of the i-th lens side in said 1st group, it is $0.30<r1/f<0.50$. ..... (4)
It is satisfying ********.
[0040] Conditional expression (4) is the thing of the positive lens of the meniscus configuration of the 1st group which restricted the convex configuration of the lens side by the side of a body most, and is related with aberration amendment of miniaturization of a lens system, good spherical aberration, and a tangential-image-surface bow. If it tends to become difficult to shorten an optical overall length when a maximum is surpassed and curvature becomes large, and it is going to shorten this by force, a positive lens will become close to a planoconvex configuration, and positive distortion aberration and the aberration of a negative tangential-image-surface bow will generate it. Moreover, if a minimum is surpassed and curvature becomes small, a positive lens will serve as a strong meniscus configuration, and aberration amendment of the high order negative spherical aberration generated with a positive lens and a high order positive tangential-image-surface bow will become difficult.
[0041] (**-2) When the focal distance of said 2nd group is set to f2, it is $-1.50<f2/f<-0.3$. ..... (5)

It is satisfying ********.
[0042] Conditional expression (5) is a formula which has specified the focal distance of the 2nd group which is a divergent lens (negative lens) only [in this optical system]. If a maximum is surpassed and a focal distance becomes long, while sufficient back focus will no longer be obtained, the PETTSU bar sum becomes large and it becomes impossible to maintain high optical-character ability. Moreover, if a minimum is surpassed and a focal distance becomes short, it will become difficult to suppress generating of many aberration and to obtain good optical-character ability. Amending becomes difficult, even if too much spherical aberration occurs and it uses the aspheric surface especially.
[0043] (**-3) As for said 2nd group, a concave negative lens and both the concave lens side consist [both the lens side] of the cemented lens of a convex positive lens, and said 3rd group is that both the lens side consists of the convex positive lens.
[0044] Next, the features other than the configuration which the taking lens of this invention mentioned above are explained.
[0045] As mentioned above, in order to detach an exit pupil enough from the image surface, as for the last lens of a back group at least, considering as a positive lens is desirable. Moreover, it is good to make lens number of sheets into the minimum, for shortening an overall length, and after using the last lens as a positive lens with the pre-group which consists of taking lenses of this invention with one positive lens, it constitutes from a group. Moreover, in order not to strengthen the refractive power of the last lens extremely but to detach an exit pupil from the image surface, the negative cemented lens which is a lens in front of the last lens makes the convex the lens side by the side of the image surface.
[0046] Moreover, in order to make an image surface property good, the negative cemented lens is arranged in a back group. As for the pre-group, within the 1st group, the amendment to the PETTSU bar sum is not made for one lens.
[0047] Therefore, it cancels by the pre-group and the back group by setting up negative refractive power into a back group, and the PETTSU bar sum is made small in the whole system.
[0048] Moreover, since the 2nd lens and the 3rd lens are stuck on order compared with the taking lens of the four four groups configuration of a positive lens, a negative lens, a positive lens, and a positive lens from a body side and it is considering as the cemented lens, it is considering as the configuration without the air gap section with the high eccentric sensitivity in the taking lens of a four four groups configuration.
[0049] Therefore, there is an advantage that there is little deterioration of the image formation engine performance by the manufacture error, an assembly error, etc., through the whole system.

[0050] Moreover, the taking lens of this invention is stopped down between the 1st group 103 and the 2nd group 104, and has SP. As for drawing, for separating ****** from the image surface, being arranged more at a body side is desirable, and drawing is arranged to the image surface side of the 1st group in the taking lens of this invention.
[0051] Moreover, if drawing is arranged between the 2nd group 104 and the 3rd group 105, in order to separate an exit pupil from the image surface, carrying out overall-length compaction, the refractive power of the 3rd group will become strong too much, and cannot make the PETTSU bar sum small.
[0052] Therefore, as for drawing, between the 1st group and the 2nd group is good for being compatible in overall-length compaction and an exit pupil.
[0053] Moreover, as for the positive lens of the 1st group, it is good for an image surface side that it is the meniscus configuration which has a concave surface. It is necessary to give the operation which makes the chief ray outside a shaft crooked to separate an exit pupil from the image surface to the lens of the 1st group to some extent.
[0054] Therefore, although a certain amount of refractive power is required for the lens of the 1st group, in the lens of the 1st group, it is easy to generate slack type distortion aberration as a result. In order to make generating of this distortion aberration into the minimum, it is effective when the chief ray of an axial outdoor daylight bunch makes min the angle which carries out incidence to a lens side.

[0055] For example, although whenever [incident angle / of concentric radius of curvature, then an axial outdoor daylight line] can be performed with 0, it cannot have positive refractive power of the degree which is this.
[0056] Therefore, at the taking lens of this invention, the distortion aberration which maintains the meniscus configuration which has a convex strong against a body side, and is generated by the back group although the lens side by the side of a body is small in radius of curvature to a concentric configuration, the lens side by the side of the image surface enlarges radius of curvature and refractive power is strengthened is canceled, and generating of the distortion aberration of the whole system is made into the minimum. And aberration amendment is performed by the back group so that this may be canceled.
[0057] Moreover, the taking lens of this invention is good to use the aspheric surface for the 3rd group 103 which is the last lens, according to this, an overall length is shortened further and the good image formation engine performance is obtained.
[0058] It is necessary to strengthen the refractive power of the last lens with the above-mentioned three four groups configuration to carry out the difficulty of the exit pupil from the image surface, and shorten an overall length. Although slack type distortion aberration and the curvature of field of an undershirt arise at this time, it is good to use the aspheric surface for amending this aberration at the last lens. Overall-length compaction can be enabled more nearly further than the configuration of only a spherical lens, amending many aberration according to this.
[0059] It is more effective, when setting the aspheric surface as the last lens and it is the configuration to which astriction (positive refractive power) becomes weaker toward the circumference from an optical axis to amend slack type distortion aberration.
[0060] This is the configuration to which curvature becomes loose in a convex. If it does in this way, it will work so that the curvature of a lens side and the incident angle of a beam of light may weaken crookedness to an axial outdoor daylight line, and slack type distortion aberration will be amended.
[0061] Moreover, since an image formation operation becomes weaker to an axial outdoor daylight bunch, it is tended to amend the curvature of field of an undershirt. Therefore, in the taking lens of this invention, distortion aberration and a curvature of field can both be amended good, carrying out [it is good to use such the aspheric surface for the last lens, and] overall-length compaction according to this.
[0062] In addition, although surrounding refractive power becomes weaker relatively to near an optical axis with the above-mentioned aspheric surface configuration, aberration amendment is possible, fully separating an exit pupil from the image surface, since the refractive power of the 3rd group itself is strengthened by aspheric surface installation.
[0063] Moreover, it is effective, when the aspheric surface is used also for the 1st group 103 in addition to the 3rd group 105 for making a photography field angle into a wide angle more. At a certain fixed overall length, it is necessary to strengthen the refractive power of the 1st group, so that a photography field angle turns into a wide angle. By the 1st group, although slack type distortion aberration occurs, if refractive power is too strong, even if it will use the aspheric surface for the 3rd group, it becomes the lack of amendment.
[0064] In such a case, if the aspheric surface is used for the 1st group, amendment of distortion aberration will be attained, considering as a wide angle taking lens.
[0065] As stated above, the 1st group is the meniscus lens which strengthened positive refractive power to the concentric configuration. Therefore, in respect of the lens of the 1st group, a chief ray is crooked by as big the incident angle as an axial outdoor daylight bunch. It is good to consider as the aspheric surface where transpiration becomes weaker gradually toward the circumference from an optical axis to amend slack type distortion aberration.
[0066] That is, it is good to consider as the aspheric surface where curvature becomes tight toward the circumference from an optical axis, and to consider as an aspheric surface configuration to which curvature becomes loose toward the circumference from an optical axis in the lens side by the side of the image surface in the lens side by the side of the body of the 1st group.

[0067] Next, the numerical example of this invention is shown. a numerical example -- setting -- Ri -- a body side -- the i-th, the i+1st gaps, nickel, and nui are the radius of curvatures of the i-th field, and Di is the refractive index and the Abbe number of the i-th optical member in order from an each body side in a body side.
[0068] Moreover, the value of the monograph affair type in each numerical example is shown in a table 1.
[0069]
[Numerical example 1]
f= 16.11500 fno=1:2.8 2 omega= 21.7-degreeR 1= 6.257 D 1= 1.86 N 1=1.62299 nu 1= 58.2R 2= 11.125 D 2= 4.65R 3= (drawing) D 3= 2.60R 4= -3.817 D 4= 2.20 N 2=1.76182 nu 2= 26.5R 5= 7.499 D 5= 3.40 N 3=1.62374 nu 3= 47.1R 6= -7.499 D 6= 0.20R 7= 17.791 7= 2.02 N D 4= 1.83400 nu 4= 37.2R 8=-17.791 D 8= 0.80R 9= infinity D 9= 3.10 N 5=1.51633 nu 5= 64.1R10= infinity [Numerical example 2]
f= 16.10357 fno=1:2.8 2 omega= 21.4-degreeR 1= 4.829 D 1= 1.86 N 1=1.62145 nu 1= 59.6R 2= 13.200 D 2= 1.97R 3= (drawing) D 3= 2.60R 4= -3.250 D 4= 2.20 N 2=1.84773 nu 2= 24.0R 5= 6.995 D 5= 3.40 N 3=1.59477 nu 3= 60.1R 6= -6.995 D 6= 0.20R 7= 16.311 7= 2.48 N D 4= 1.86057 nu 4= 28.3R 8=-16.311 D 8= 0.80R 9= infinity D 9= 3.10 N 5=1.51633 nu 5= 64.1R10= infinity [Numerical example 3]
f= 15.84959 fno=1:2.8 2 omega= 22.0-degreeR 1= 7.624 D 1= 1.86 N 1=1.84773 nu 1= 24.1R 2= 7.690 D 2= 4.81R 3= (drawing) D 3= 2.60R 4= -6.181 D 4= 2.20 N 2=1.81908 nu 2= 27.4R 5= 9.214 D 5= 3.40 N 3=1.63911 nu 3= 50.4R 6= -9.214 D 6= 0.20R 7= 21.095 7= 2.34 N D 4= 1.88308 nu 4= 40.8R 8=-21.095 D 8= 0.80R 9= infinity D 9= 3.10 N 5=1.51633 nu 5= 64.1R10= infinity
[Numerical example 4]
f= 16.21736 fno=1:2.8 2 omega= 21.6-degreeR 1= 6.581 D 1= 1.86 N 1=1.57491 nu 1= 41.7R 2= 8.705 D 2= 5.10R 3= (drawing) D 3= 2.60R 4= -4.779 D 4= 2.20 N 2=1.74324 nu 2= 29.3R 5= 8.333 D 5= 3.40 N 3=1.59513 nu 3= 56.2R 6= -8.333 D 6= 0.20R 7= 20.439 7= 1.78 N D 4= 1.88314 nu 4= 40.8R 8=-20.439 D 8= 0.80R 9= infinity D 9= 3.10 N 5=1.51633 nu 5= 64.1R10= infinity
[Numerical example 5]
f= 15.73256 fno=1:2.8 2 omega= 22.0-degreeR 1= 5.097 D 1= 1.86 N 1=1.69881 nu 1= 55.4R 2= 9.622 D 2= 2.68R 3= (drawing) D 3= 2.60R 4= -3.066 D 4= 2.20 N 2=1.84782 nu 2= 23.8R 5= 6.944 D 5= 3.40 N 3=1.71218 nu 3= 54.2R 6= -6.944 D 6= 0.20R 7= 16.486 7= 2.54 N D 4= 1.80081 nu 4= 26.4R 8=-16.486 D 8= 0.80R 9= infinity D 9= 3.10 N 5=1.51633 nu 5= 64.1R10= infinity [0070]
[A table 1]

条件式	実施例1	実施例2	実施例3	実施例4	実施例5
(1) 0.7< | f1 | /f<5.0	1.24	0.70	4.75	2.19	0.84
(2) -5.0<φ2a•f<-2.0	-3.22	-4.20	-2.10	-2.52	-4.35
(3) 1.0<φ3•f<2.0	1.47	1.64	1.29	1.37	1.48
(4) 0.30<r1/f<0.50	0.39	0.30	0.48	0.41	0.32
(5) -1.50<f2/f<-0.3	-0.78	-0.44	-1.20	-0.96	-0.61

[0071]
[Effect of the Invention] specifying each element as mentioned above according to this invention -- an overall length -- being shortened -- an exit pupil -- from the image surface -- enough -- detaching -- in addition -- and the taking lens which has good optical-character ability can be attained.

[Translation done.]

* NOTICES *

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2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The lens cross section of the numerical example 1 of this invention
[Drawing 2] Aberration drawing of the numerical example 1 of this invention
[Drawing 3] The lens cross section of the numerical example 2 of this invention
[Drawing 4] Aberration drawing of the numerical example 2 of this invention
[Drawing 5] The lens cross section of the numerical example 3 of this invention
[Drawing 6] Aberration drawing of the numerical example 3 of this invention
[Drawing 7] The lens cross section of the numerical example 4 of this invention
[Drawing 8] Aberration drawing of the numerical example 4 of this invention
[Drawing 9] The lens cross section of the numerical example 5 of this invention
[Drawing 10] Aberration drawing of the numerical example 5 of this invention
[Description of Notations]
101 Pre-group
102 Back Group
103 1st Group
104 2nd Group
105 3rd Group
107 Glass Block
108 Image Surface
SP Aperture diaphragm
deltaS Sagittal image surface
deltaM Meridional image surface

[Translation done.]

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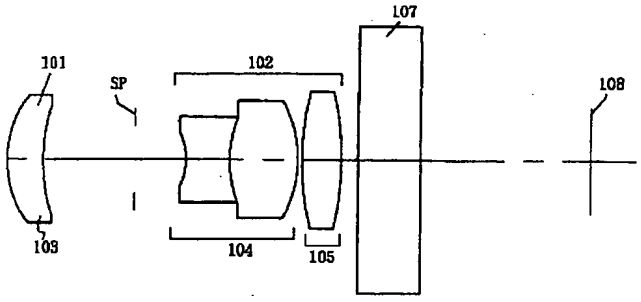
Ｆターム(参考)　2H087 KA02 KA03 LA01 PA03 PA18 PB04 QA02 QA07 QA12 QA22 QA25 QA34 QA41 QA46 RA32 RA42

(54)【発明の名称】　撮影レンズ

(57)【要約】
【課題】全体として４枚のレンズより成り、テレセントリック性の良い高い光学性能を有した撮影レンズを得ること。
【解決手段】物体側から順に、像側に凹面を向けたメニスカス状のレンズより成る第１群、両レンズ面が凹面の負レンズと正レンズとを接合した接合レンズより成る第２群、正レンズより成る第３群で構成され、第１群と第２群の間に開口絞りを有する撮影レンズにおいて、全系の焦点距離ｆ、第１群の焦点距離ｆ１、第２群の物体側のレンズ面の屈折力φ２ａ、第３群の屈折力φ３を各々適切に設定したこと。



【特許請求の範囲】
【請求項１】　物体側から順に、像側に凹面を向けたメニスカス状の正レンズより成る第１群、両レンズ面が凹面の負レンズと正レンズとを接合した接合レンズより成る第２群、正レンズより成る第３群で構成され、第１群と第２群の間に開口絞りを有する撮影レンズにおいて、全系の焦点距離をｆ、第１群の焦点距離をｆ１、第２群の物体側のレンズ面の屈折力をφ２ａ、第３群の屈折力をφ３としたとき、
０．７＜｜ｆ１｜／ｆ＜　５．０
－５．０＜　φ２ａ・ｆ＜－２．０
１．０＜　φ３　・ｆ＜　２．０
の条件式を満足することを特徴とする撮影レンズ。
【請求項２】　前記第１群において、ｒｉを第ｉレンズ面の曲率半径としたとき、
０．３０＜ｒ１／ｆ＜０．５０
の条件式を満足することを特徴とする請求項１の撮影レンズ。
【請求項３】　前記第２群の焦点距離をｆ２としたとき、
－１．５０＜ｆ２／ｆ＜－０．３
の条件式を満足することを特徴とする請求項１又は２の撮影レンズ。
【請求項４】　前記第２群は両レンズ面が凹面の負レンズと両レンズ面が凸面の正レンズの接合レンズより成り、前記第３群は両レンズ面が凸面の正レンズより成っていることを特徴とする請求項１，２又は３の撮影レンズ。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明はデジタルスチルカメラ、ビデオカメラ、放送用カメラ、写真用カメラ等に用いられる撮影レンズに関するものである。
【０００２】
【従来の技術】近年、コンピュータの画像入力機器としてデジタルスチルカメラが普及しつつある。このデジタルスチルカメラではＣＣＤ等の固体撮像素子からの出力信号をＡＤ変換して画像データとし、これをＪＰＥＧ等の圧縮処理を行い、フラッシュメモリー等の記録媒体に記録するといった処理が一般的に行われている。このようにして記録された圧縮データはコンピュータ上で展開された後、モニタ等に表示されている。
【０００３】このようなデジタルスチルカメラにおいては撮影画像の高精細化と装置の小型化が課題となっており、撮影系には高解像力と小型化の両立が求められている。特に携帯性を重視して薄型のカメラとするには、撮影系には全長（第１レンズ面から像面までの距離）の短縮化が要求される。全長を短縮するにはできるだけ構成レンズ枚数の少ない撮影レンズを用いると有利である。
【０００４】このような小型の撮影レンズとして、特開平９－２５８１００号公報には物体側から順に両レンズ面が凸面の正レンズ、物体側に強い凹面を向けた両レンズ面が凹面の負レンズ、像側に強い凸面を向けた正レンズ、物体側に強い凸面を向けた正レンズの４群４枚構成が、特開平２－１３７８１２号公報には物体側から順に正レンズ、負レンズ、正レンズ、正レンズの４群４枚構成が、特開昭６４－９０４０９号公報には物体側から順に物体側に凸面を向けたメニスカス状の正レンズ、像側に強い曲率の面を向けた負レンズ、物体側に凸面を向けたメニスカス状の正レンズ、正レンズの４群４枚構成が開示されている。これらはいずれも４群４枚構成であり、単焦点レンズである。
【０００５】
【発明が解決しようとする課題】固体撮像素子を用いた撮影系では、像面から射出瞳までの距離が短いと軸外光線（軸外主光線）の受光面への入射角が大きくなるため、シェーディング等の問題が発生する。よってこのような固体撮像素子に用いる撮影レンズは、射出瞳が像面より十分に離れているテレセントリックな光学系が良い。
【０００６】具体的には、撮影レンズは、光軸と撮影画角に相当する角度をなして入射した軸外光束主光線が光軸と略平行となって結像面に至るように構成されているのが良い。撮影画角が広画角となる程、光軸と平行となるまで軸外主光線を屈曲するために必要な屈折力は強まる。
【０００７】一般的に、半画角が５０度を超えるような広角レンズでなければ、絞りより物体側では負の屈折力により、又絞りより像面側では正の屈折力により軸外主光線の光軸となす角度を小さくする、すなわち平行に近づける光学作用を強くする必要はない。
【０００８】よって、レトロフォーカス型の撮影レンズの様に、絞りより物体側に負の屈折力の前群を配置しなくとも、正のパワーを持つ前群により軸外主光線の光軸となす角度を小さくすることができると共に、歪曲収差を良好に補正することができる。正の屈折力の後群においては絞りより像面側の正レンズにより軸外主光線の光軸となす角度を小さくすることができる。
【０００９】よって、半画角が５０度を超えるような広角レンズでなければ、前群に凹レンズを配さなくても、後群で射出瞳を像面から離す効果があるため、テレセントリックな射出瞳と長いバックフォーカスが必要な小型の光学系を達成することができる。
【００１０】さらに、全長を短縮して射出瞳を像面より十分に離すには、少なくとも後群の最終レンズは正レンズとすることが必要である。
【００１１】さらに好ましくは最終レンズの直前のレンズの像面側のレンズ面は像面に向かって凸面であるのがよい。
【００１２】このようにすると軸外主光線を屈曲させる

作用を最終レンズを含め三つのレンズ面で分担できるため、最終レンズの屈折力が極端に強くならずにすむ。最終レンズの屈折力が強すぎると樽型の歪曲収差および非点収差が発生するためよくない。

【００１３】さらに望ましくは最も像面側のレンズは、両レンズ面が凸面で曲率半径が同一又は略同一とすることである。製作上で両凸レンズを同じ曲率半径にすることは、鏡筒組み込み時、研磨時に製作を容易にすることができる。

【００１４】さらに望ましくは、最も像面側のレンズの次に像面に近いレンズを両レンズ面が凸面で曲率半径が同一又は略同一とすることである。両凸レンズを同じ曲率半径にすることは、鏡筒組み込み時、研磨時に製作を容易にすることができる。

【００１５】さらに、像面の平坦性を良好にするにはペッツバール和をある程度小さくすることが必要である。前記後群中に負の屈折力がない場合、ペッツバール和を小さくするには前群の第１レンズの屈折力をかなり強める必要がある。第１レンズの屈折力をこのように強めると、結果として非常に大きな樽型の歪曲収差が発生する。デジタルスチルカメラを含む一般的なカメラにおいては大きな歪曲収差は望ましくない。後群に負の屈折力を有する場合は、後群内のペッツバール項をある程度コントロールすることができる。

【００１６】レンズ１枚で構成される前群のペッツバール項は群内で補正されないので、前群を補正するように後群のペッツバール項を設定すればよい。よって良好な像面特性を得るには、後群には少なくとも凹レンズ（負レンズ）を１枚もしくは負の屈折力を有する接合レンズを１群有することが必要である。

【００１７】特開平９－２５８１００号公報では、負の第３レンズと正の第４レンズ間の空気間隔の各収差に対する敏感度が大きい。特に球面収差と像面湾曲に対する敏感度の符号が異なるため、上記空気間隔が設計値よりずれると設計上のベストピント面に対し画面中心、画面周辺のベストピント位置は光軸方向で逆方向にずれる。

【００１８】結果として像面湾曲が発生し、画面中心にピントを合わせた場合は画面周辺では解像力不足となる。これを防ぐには製造において上記空気間隔に対する公差を非常に厳しく管理する必要があり、製造コストアップにつながる。

【００１９】また、特開平２－１３７８１２号公報では、内視鏡・顕微鏡・双眼鏡・望遠鏡等の接眼部に取り付けて撮影を行うカメラを想定しており、通常のカメラ用として考えれば、必要以上にバックフォーカスが長く、光学全長は長くなる。

【００２０】また、特開昭６４－９０４０９号公報では、後絞りを想定しており、レンズの特性上、テレ比１．０程度では、歪曲収差・像面湾曲の補正が難しい。軸上色収差も補正が足りない。

【００２１】本発明は、全長を短縮し、射出瞳を像面から十分に離し、なおかつ良好な光学性能を有する撮影レンズの提供を目的とする。

【００２２】

【課題を解決するための手段】請求項１の発明の撮影レンズは、物体側から順に、像側に凹面を向けたメニスカス状の正レンズより成る第１群、両レンズ面が凹面の負レンズと正レンズとを接合した接合レンズより成る第２群、正レンズより成る第３群で構成され、第１群と第２群の間に開口絞りを有する撮影レンズにおいて、全系の焦点距離をｆ、第１群の焦点距離をｆ１、第２群の物体側のレンズ面の屈折力をφ２ａ、第３群の屈折力をφ３としたとき、

０．７＜｜ｆ１｜／ｆ＜５．０　　……（１）

－５．０＜　φ２ａ・ｆ＜－２．０　　……（２）

１．０＜　φ３　・ｆ＜　２．０　　……（３）

の条件式を満足することを特徴としている。

【００２３】請求項２の発明は請求項１の発明において、前記第１群において、ｒｉを第ｉレンズ面の曲率半径としたとき、

０．３０＜ｒ１／ｆ＜０．５０　　……（４）

の条件式を満足することを特徴としている。

【００２４】請求項３の発明は請求項１又は２の発明において、前記第２群の焦点距離をｆ２としたとき、

－１．５０＜ｆ２／ｆ＜－０．３　　……（５）

の条件式を満足することを特徴としている。

【００２５】請求項４の発明は請求項１，２又は３の発明において、前記第２群は両レンズ面が凹面の負レンズと両レンズ面が凸面の正レンズの接合レンズより成り、前記第３群は両レンズ面が凸面の正レンズより成っていることを特徴としている。

【００２６】

【発明の実施の形態】図１，図３，図５，図７，図９は本発明の撮影レンズの数値実施例１～５のレンズ断面図、図２，図４，図６，図８，図１０は本発明の撮影レンズの数値実施例１～５の収差図である。

【００２７】レンズ断面図において１０１は正の屈折力の前群、１０２は全体として負の屈折力の後群である。１０３は正の屈折力の第１群、１０４は負の屈折力の第２群、１０５は正の屈折力を有する第３群、１０７は水晶ローパスフィルター、赤外カットフィルター等で構成されるフィルター群、１０８は結像面、ＳＰは開口絞りである。

【００２８】本発明の撮影レンズは物体側より順に、正の屈折力の第１群１０３、全体として負の屈折力の第２群１０４、正の屈折力の第３群１０５から成っている。そして正の屈折力の第１群１０３は像面側に凹面を向けたメニスカス状の正レンズから成り、第２群１０４は両レンズ面が凹面の負レンズと正レンズが凸面の正レンズの接合レンズより成り、第３群１０５は両レンズ面が凸

面の正レンズから成り、全系は３群４枚で構成されている。

【００２９】そして前述の条件式（１）～（３）を満足させることにより、射出瞳を像面から遠ざけてテレセントリック性を良好に維持しつつ、高い光学性能を得ている。

【００３０】次に前述の各条件式について説明する。

【００３１】条件式（１）は第１群の焦点距離すなわち屈折力を規定している式である。

【００３２】上限をこえて屈折力が弱まると第１群にて射出瞳を像面から遠ざける作用が弱まる。これを補うように後群の屈折力にて射出瞳を像面から遠ざけようとすると、後群中の凸面の屈折力を強めなければならず、ペッツバール和を小さくすることができなくなり像面湾曲が発生するためよくない。また、後群の屈折力を強めないで射出瞳を像面から遠ざけようとすると、全長が長くなりコンパクトなカメラを構成できない。

【００３３】また下限をこえて屈折力が強まると、第１群にて歪曲収差、非点収差が過度に発生し非球面を用いても補正困難となりよくない。また、バックフォーカスが短くなり光学全長を短縮するのが困難となる。

【００３４】条件式（２）は第２群の物体側のレンズ面の屈折力（焦点距離の逆数）を規定している式であり、主に球面収差の補正およびペッツバール和を諸収差とのバランスで最適な値にする為の数値範囲である。

【００３５】上限をこえて屈折力が弱まると、他の正レンズで発生した球面収差を補正しきれなくなると共にペッツバール和が大きくなり像面湾曲が補正不足となる。また、下限を超えて屈折力が強まると球面収差が補正過剰となるばかりでなく、コマ収差の発生も伴ってしまい好ましくないと共に、ペッツバール和が負の値に大きくなり像面湾曲が補正過剰となる。

【００３６】条件式（３）は第３群の焦点距離の逆数すなわち屈折力を規定している式である。

【００３７】上限をこえて屈折力が弱まるとバックフォーカスが長くなり光学全長を短縮することが困難となる。また下限をこえて屈折力が強まると諸収差の発生を抑えて良好な光学性能を得ることが困難となる。特に過度の球面収差が発生し非球面を用いても補正困難となる。

【００３８】本発明の撮影レンズでは以上のような構成により、画面全体にわたり高い光学性能を有しているが、更に好ましくは次の構成のうち、少なくとも１つを満足させるのが良い。

【００３９】（アー１）前記第１群において、ｒｉを第ｉレンズ面の曲率半径としたとき、

０．３０＜ｒ１／ｆ＜０．５０　　……（４）

の条件式を満足することである。

【００４０】条件式（４）は、第１群のメニスカス形状の正レンズの最も物体側のレンズ面の凸形状を制限したもので、レンズ系のコンパクト化と良好な球面収差および子午像面湾曲の収差補正に関するものである。上限をこえて曲率が大きくなると光学全長を短縮することが困難となり、これを無理に短縮しようとすると、正レンズは平凸形状に近くなり、正の歪曲収差と、負の子午像面湾曲の収差が発生する。また下限をこえて曲率が小さくなると正レンズは強いメニスカス形状となり、正レンズで発生する高次の負の球面収差と高次の正の子午像面湾曲の収差補正が困難となる。

【００４１】（アー２）前記第２群の焦点距離をｆ２としたとき、

－１．５０＜ｆ２／ｆ＜－０．３　　……（５）

の条件式を満足することである。

【００４２】条件式（５）はこの光学系中唯一の発散レンズ（負レンズ）である第２群の焦点距離を規定している式である。上限をこえて焦点距離が長くなると十分なバックフォーカスが得られなくなるとともに、ペッツバール和が大きくなり高い光学性能を維持出来なくなる。また下限をこえて焦点距離が短くなると諸収差の発生を抑えて良好な光学性能を得ることが困難となる。特に過度の球面収差が発生し非球面を用いても補正困難となる。

【００４３】（アー３）前記第２群は両レンズ面が凹面の負レンズと両レンズ面が凸面の正レンズの接合レンズより成り、前記第３群は両レンズ面が凸面の正レンズより成っていることである。

【００４４】次に本発明の撮影レンズの前述した構成以外の特徴について説明する。

【００４５】前述のように、射出瞳を像面より十分離すには、少なくとも後群の最終レンズは正レンズとすることが望ましい。また全長を短縮するにはレンズ枚数を最小限とするのがよく、本発明の撮影レンズでは正レンズ１枚で構成される前群と、最終レンズを正レンズとした後群で構成している。また、最終レンズの屈折力を極端に強めず射出瞳を像面より離すために、最終レンズの直前のレンズである負の接合レンズは像面側のレンズ面を凸面としている。

【００４６】また、像面特性を良好とするために後群中に負の接合レンズを配置している。前群はレンズ１枚のため第１群内ではペッツバール和に対する補正がなされていない。

【００４７】よって後群中に負の屈折力を設定することで前群と後群でキャンセルして全系でペッツバール和を小さくしている。

【００４８】また、物体側から順に正レンズ、負レンズ、正レンズ、正レンズの４群４枚構成の撮影レンズに比べ第２レンズと第３レンズを貼り合わせて接合レンズとしているため、４群４枚構成の撮影レンズにおける偏芯敏感度の高い空気間隔部がない構成としている。

【００４９】よって、全系を通して製造誤差、組み立て

誤差等による結像性能の劣化が少ないという利点がある。

【００５０】また、本発明の撮影レンズは第１群１０３と第２群１０４の間に絞りＳＰを有する。射出瞳を像面から離すには絞りはより物体側に配置されるのが好ましく、本発明の撮影レンズでは絞りは第１群の像面側に配置している。

【００５１】また第２群１０４と第３群１０５の間に絞りを配置すると、全長短縮しながら射出瞳を像面から離すためには第３群の屈折力が過度に強まってしまいペッツバール和を小さくできない。

【００５２】よって、全長短縮と射出瞳を両立するに絞りは第１群と第２群の間がよい。

【００５３】また、第１群の正レンズは像面側に凹面を有するメニスカス形状であるのがよい。射出瞳を像面から離すには軸外主光線を屈曲させる作用を第１群のレンズにある程度持たせる必要がある。

【００５４】よって、第１群のレンズにはある程度の屈折力が必要であるが、結果として第１群のレンズにおいて樽型の歪曲収差が発生しやすい。この歪曲収差の発生を最小限とするには、軸外光束の主光線がレンズ面へ入射する角度を最小とすると効果がある。

【００５５】例えばコンセントリックな曲率半径とすれば軸外光線の入射角度を０とできるが、これではある程度の正の屈折力を有することができない。

【００５６】よって本発明の撮影レンズではコンセントリックな形状に対して物体側のレンズ面は曲率半径を小さく、像面側のレンズ面は曲率半径を大きくして屈折力を強めるものの、物体側に強い凸面を有するメニスカス形状を維持して後群で発生する歪曲収差をキャンセルし、全系の歪曲収差の発生を最小限としている。そして、これをキャンセルするように後群にて収差補正を行っている。

【００５７】また、本発明の撮影レンズは最終レンズである第３群１０３に非球面を用いるのが良く、これによればさらに全長を短縮して良好な結像性能が得られる。

【００５８】上記３群４枚構成では射出瞳を像面から離して全長を短縮するには最終レンズの屈折力を強める必要がある。このとき樽型の歪曲収差およびアンダーの像面湾曲が生じるが、この収差を補正するには最終レンズに非球面を用いるのが良い。これによれば諸収差を補正しながら球面レンズのみの構成よりもさらに全長短縮を可能とすることができる。

【００５９】最終レンズに非球面を設定する場合、樽型の歪曲収差を補正するには光軸から周辺に向かって収斂作用（正の屈折力）が弱まるような形状とすると、より効果がある。

【００６０】これは凸面においては曲率が緩くなるような形状である。このようにすると、レンズ面の曲率、光線の入射角ともに軸外光線に対して屈曲を弱めるよう働き樽型の歪曲収差が補正される。

【００６１】また、軸外光束に対しては結像作用が弱まるためアンダーの像面湾曲を補正する方向にある。よって、本発明の撮影レンズでは最終レンズにこのような非球面を用いるのが良く、これによれば全長短縮しながら歪曲収差と像面湾曲をともに良好に補正することができる。

【００６２】なお、上記非球面形状により光軸付近に対して周辺の屈折力は相対的に弱まるが、非球面導入により第３群の屈折力そのものは強められるため射出瞳を像面から十分に離したまま収差補正が可能である。

【００６３】また、撮影画角をより広角とするには第３群１０５に加えて第１群１０３にも非球面を用いると効果がある。ある一定の全長では撮影画角が広角になるほど第１群の屈折力を強める必要がある。第１群では樽型の歪曲収差が発生するが屈折力が強すぎると第３群に非球面を用いても補正不足となる。

【００６４】このような場合は第１群に非球面を用いると、より広角な撮影レンズとしながら歪曲収差が補正可能となる。

【００６５】前に述べたように、第１群はコンセントリックな形状に対して正の屈折力を強めたメニスカスレンズである。よって、第１群のレンズ面では軸外光束ほど大きな入射角で主光線が屈曲する。樽型の歪曲収差を補正するには光軸から周辺に向かってしだいに発散作用が弱まるような非球面とするのがよい。

【００６６】すなわち、第１群の物体側のレンズ面では光軸から周辺に向かって曲率がきつくなるような非球面とし、また、像面側のレンズ面では光軸から周辺に向かって曲率がゆるくなるような非球面形状とするのが良い。

【００６７】次に本発明の数値実施例を示す。数値実施例においてＲｉは物体側より第ｉ番目の面の曲率半径、Ｄｉは物体側より順に第ｉ番目と第ｉ＋１番目の間隔、Ｎｉとνｉは各々物体側より順に第ｉ番目の光学部材の屈折率とアッベ数である。

【００６８】また、表１に各数値実施例における各条件式の値を示す。

【００６９】

［数値実施例１］

f=16.11500　　fno=1:2.8　　2ω=21.7°

R 1=　6.257　　D 1= 1.86　　N 1=1.62299　　ν 1= 58.2

R 2=　11.125　　D 2= 4.65

R 3=　（絞り）　　D 3= 2.60

R 4= -3.817	D 4= 2.20	N 2=1.76182	ν 2= 26.5
R 5= 7.499	D 5= 3.40	N 3=1.62374	ν 3= 47.1
R 6= -7.499	D 6= 0.20		
R 7= 17.791	D 7= 2.02	N 4=1.83400	ν 4= 37.2
R 8= -17.791	D 8= 0.80		
R 9= ∞	D 9= 3.10	N 5=1.51633	ν 5= 64.1
R10= ∞			

［数値実施例２］

f=16.10357 fno=1:2.8 2ω=21.4°

R 1= 4.829	D 1= 1.86	N 1=1.62145	ν 1= 59.6
R 2= 13.200	D 2= 1.97		
R 3= （絞り）	D 3= 2.60		
R 4= -3.250	D 4= 2.20	N 2=1.84773	ν 2= 24.0
R 5= 6.995	D 5= 3.40	N 3=1.59477	ν 3= 60.1
R 6= -6.995	D 6= 0.20		
R 7= 16.311	D 7= 2.48	N 4=1.86057	ν 4= 28.3
R 8= -16.311	D 8= 0.80		
R 9= ∞	D 9= 3.10	N 5=1.51633	ν 5= 64.1
R10= ∞			

［数値実施例３］

f=15.84959 fno=1:2.8 2ω=22.0°

R 1= 7.624	D 1= 1.86	N 1=1.84773	ν 1= 24.1
R 2= 7.690	D 2= 4.81		
R 3= （絞り）	D 3= 2.60		
R 4= -6.181	D 4= 2.20	N 2=1.81908	ν 2= 27.4
R 5= 9.214	D 5= 3.40	N 3=1.63911	ν 3= 50.4
R 6= -9.214	D 6= 0.20		
R 7= 21.095	D 7= 2.34	N 4=1.88308	ν 4= 40.8
R 8= -21.095	D 8= 0.80		
R 9= ∞	D 9= 3.10	N 5=1.51633	ν 5= 64.1
R10= ∞			

［数値実施例４］

f=16.21736 fno=1:2.8 2ω=21.6°

R 1= 6.581	D 1= 1.86	N 1=1.57491	ν 1= 41.7
R 2= 8.705	D 2= 5.10		
R 3= （絞り）	D 3= 2.60		
R 4= -4.779	D 4= 2.20	N 2=1.74324	ν 2= 29.3
R 5= 8.333	D 5= 3.40	N 3=1.59513	ν 3= 56.2
R 6= -8.333	D 6= 0.20		
R 7= 20.439	D 7= 1.78	N 4=1.88314	ν 4= 40.8
R 8= -20.439	D 8= 0.80		
R 9= ∞	D 9= 3.10	N 5=1.51633	ν 5= 64.1
R10= ∞			

［数値実施例５］

f=15.73256 fno=1:2.8 2ω=22.0°

R 1= 5.097	D 1= 1.86	N 1=1.69881	ν 1= 55.4
R 2= 9.622	D 2= 2.68		
R 3= （絞り）	D 3= 2.60		
R 4= -3.066	D 4= 2.20	N 2=1.84782	ν 2= 23.8
R 5= 6.944	D 5= 3.40	N 3=1.71218	ν 3= 54.2

R 6= -6.944　　D 6= 0.20
R 7= 16.486　　D 7= 2.54　　N 4=1.80081　　ν 4= 26.4
R 8= -16.486　　D 8= 0.80
R 9= ∞　　D 9= 3.10　　N 5=1.51633　　ν 5= 64.1
R10= ∞

【００７０】

【表１】

条件式	実施例１	実施例２	実施例３	実施例４	実施例５
(1) 0.7< |f1| /fw<5.0	1.24	0.70	4.75	2.19	0.84
(2) -5.0<φ2a·fw<-2.0	-3.22	-4.20	-2.10	-2.52	-4.35
(3) 1.0<φ3·fw<2.0	1.47	1.64	1.29	1.37	1.48
(4) 0.30<r1/fw<0.50	0.39	0.30	0.48	0.41	0.32
(5) -1.50<f2/fw<-0.3	-0.78	-0.44	-1.20	-0.96	-0.61

【００７１】

【発明の効果】本発明によれば以上のように各要素を特定することにより、全長を短縮し、射出瞳を像面から十分に離し、なおかつ良好な光学性能を有する撮影レンズを達成することができる。

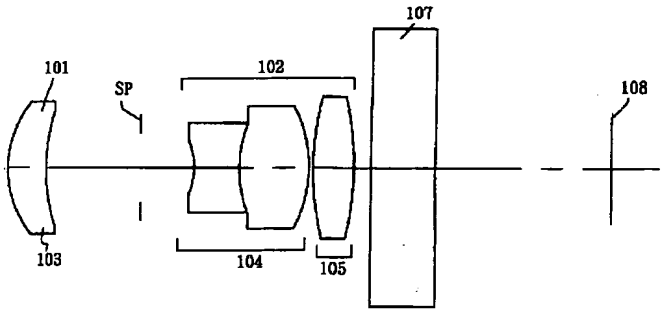
【図面の簡単な説明】

【図１】　本発明の数値実施例１のレンズ断面図
【図２】　本発明の数値実施例１の収差図
【図３】　本発明の数値実施例２のレンズ断面図
【図４】　本発明の数値実施例２の収差図
【図５】　本発明の数値実施例３のレンズ断面図
【図６】　本発明の数値実施例３の収差図
【図７】　本発明の数値実施例４のレンズ断面図
【図８】　本発明の数値実施例４の収差図
【図９】　本発明の数値実施例５のレンズ断面図
【図１０】本発明の数値実施例５の収差図

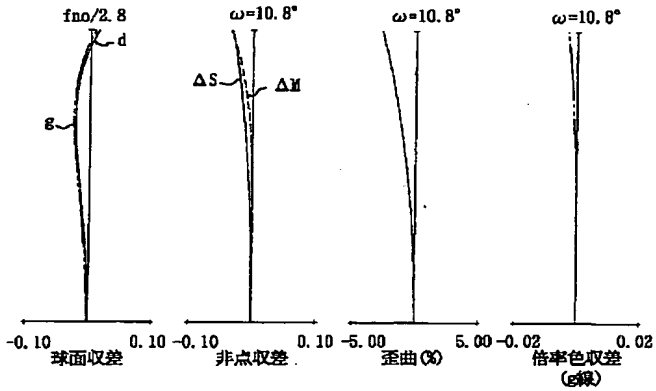
【符号の説明】

１０１　前群
１０２　後群
１０３　第１群
１０４　第２群
１０５　第３群
１０７　ガラスブロック
１０８　像面
ＳＰ　開口絞り
ΔＳ　サジタル像面
ΔＭ　メリディオナル像面

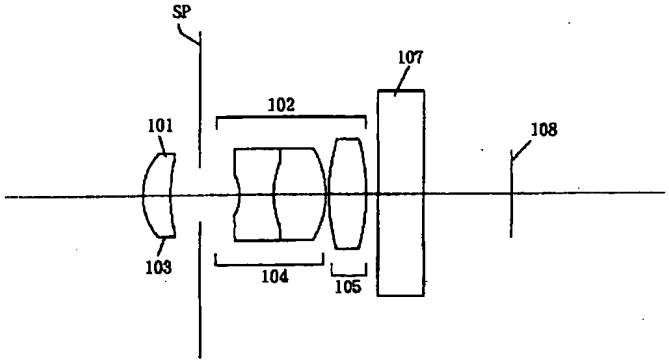
【図１】



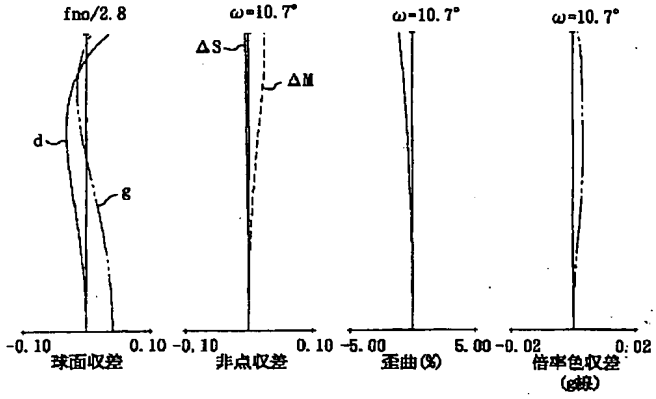
【図２】



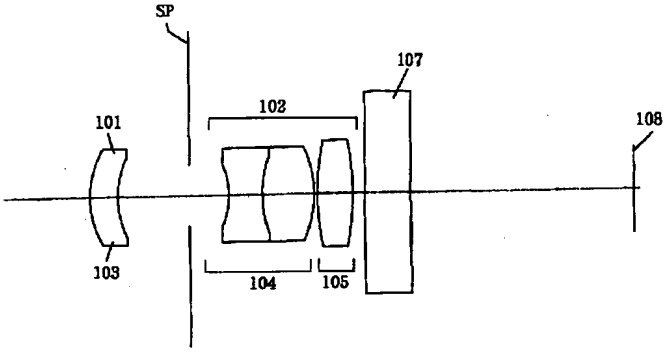
【図３】



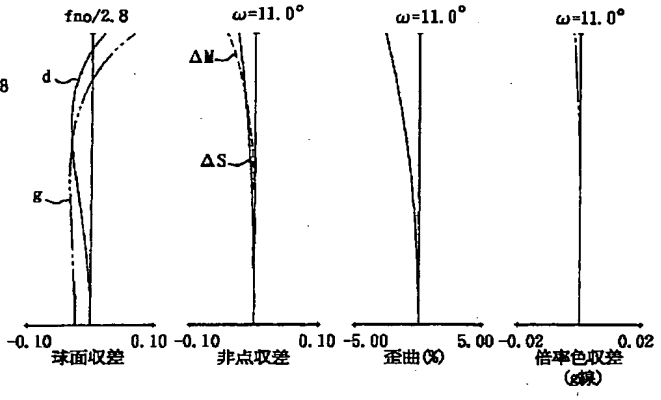
【図４】



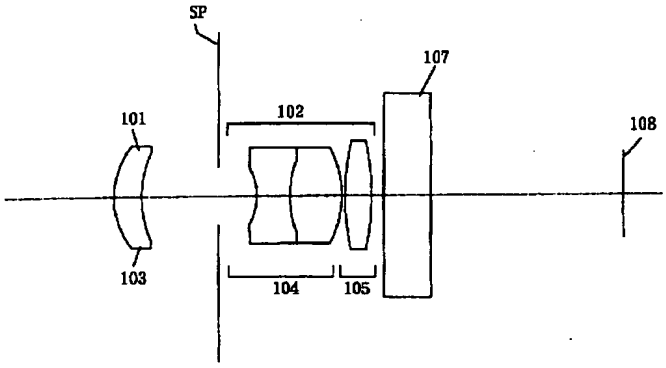
【図５】



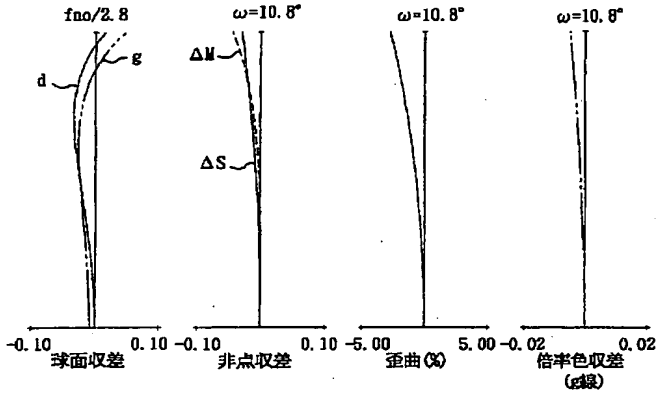
【図６】



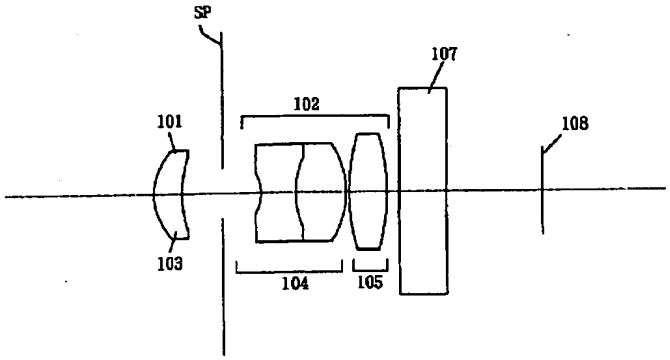
【図７】



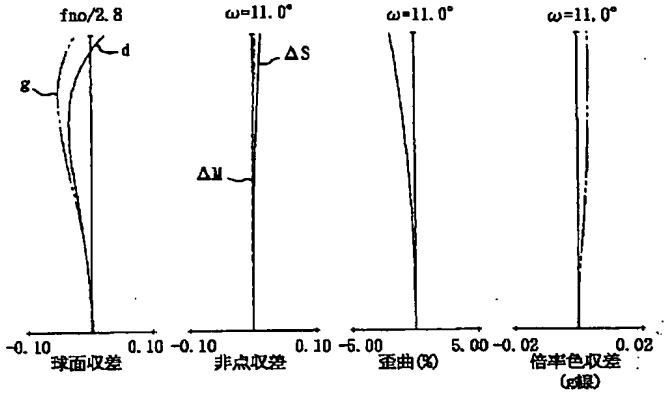
【図８】



【図９】


SP
107
102
101
108
103
104
105

【図１０】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d
g
-0.10
0.10
球面収差
ω=11.0°
ΔS
ΔM
-0.10
0.10
非点収差
ω=11.0°
-5.00
5.00
歪曲(%)
ω=11.0°
-0.02
0.02
倍率色収差
(g線)